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Space link extension — Cross support transfer service — Specification framework

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National foreword

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Foreword

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1 INTRODUCTION

1.1 PURPOSE

The purpose of this Recommended Standard is to define the various logical components, also known within this Recommended Standard as procedures that are required for specifying Cross Support Transfer Services (CSTSes).

1.2 SCOPE

1.2.1 This Recommended Standard defines, in an abstract manner, a CSTS in terms of:

a) the procedures necessary to provide the service;

b) the states of the service;

c) the behavior of each procedure;

d) the states of the procedures;

e) the operations necessary to constitute the procedures; and

f) the parameters associated with each operation.

1.2.2 It does not specify:

a) individual application services, implementations, or products;

b) the implementation of entities or interfaces within real systems;

c) the methods or technologies required to acquire data;

d) the methods or technologies required to provide a suitable environment for communications; or

e) the management activities required to schedule and configure services.

1.3 APPLICABILITY

1.3.1 APPLICABILITY OF THIS RECOMMENDED STANDARD

This Recommended Standard provides a basis for the specification and development of Cross Support Services that are intended to be used for developing real systems that implement such services.

Implementation of a service based on the CSTS procedures defined in this Recommended Standard in a real system additionally requires the availability of a communications service to convey invocations and responses of the CSTS operations between the service user and the service provider.

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This Recommended Standard requires that such a communications service provides a reliable protocol, i.e., that it ensures that invocations and responses of operations are transferred:

a) in sequence;

b) completely and with integrity;

c) without duplication;

d) with flow control that notifies the application layer in the event of congestion or backpressure; and

e) with notification to the application layer in the event that communications between the service user and the service provider are disrupted, possibly resulting in a loss of data.

It is the specific intent of this Recommended Standard to define the CSTS independently of any particular communications services, protocols, technologies, or formatting of the data content.

1.3.2 LIMITS OF APPLICABILITY

This Recommended Standard specifies the CSTS procedures that may be used for the definition of Cross Support Transfer Services. It does not intend to specify a Cross Support Transfer Service.

1.4 RATIONALE

The goal of this Recommended Standard is to create a standard for interoperability between various Agencies' tracking stations or ground data handling systems and the consumers or producers of spacecraft data and related monitor and/or control information.

1.5 DOCUMENT STRUCTURE

1.5.1 ORGANIZATION OF THIS DOCUMENT

This document is organized as follows:

a) section 1 presents the purpose, scope, applicability, and rationale of this Recommended Standard and lists the definitions, conventions, and references;

b) section 2 provides an overview of the CSTS Specification Framework;

c) section 3 specifies the common operations to be used by Cross Support Transfer Services;

d) section 4 specifies the procedures to be used by the Cross Support Transfer Services;

e) annex A contains the proforma of the Protocol Implementation Conformance Statement;

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f) annex B provides a formal specification of the production status;

g) annex C provides a formal specification of what a qualified parameter is;

h) annex D provides a formal specification of the Object Identifiers and the management of their allocation;

i) annex E defines the composition of Functional Resource Names, Parameter Names, Event Names, Parameter Lists, and Event Lists using Published Identifiers of the appropriate types;

j) annex F provides a formal specification of data types for Protocol Data Units (PDUs) for common operations using Abstract Syntax Notation One (ASN.1);

k) annex G provides a description of the service provider states;

l) annex H contains considerations related to security, SANA, and patents;

m) annex I provides a list of informative references;

n) annex J lists selected terms used in this Recommended Standard and identifies where they are defined;

o) annex K lists acronyms used in this document;

p) annex L provides an informative list of Object Identifiers used by this Recommended Standard;

q) annex M illustrates by means of examples the concept of Published Identifiers.

1.5.2 CROSS SUPPORT TRANSFER SERVICES DOCUMENTATION

The basic organization of the Cross Support Services documentation and the relationship to CSTS documentation is shown in figure 1-1.

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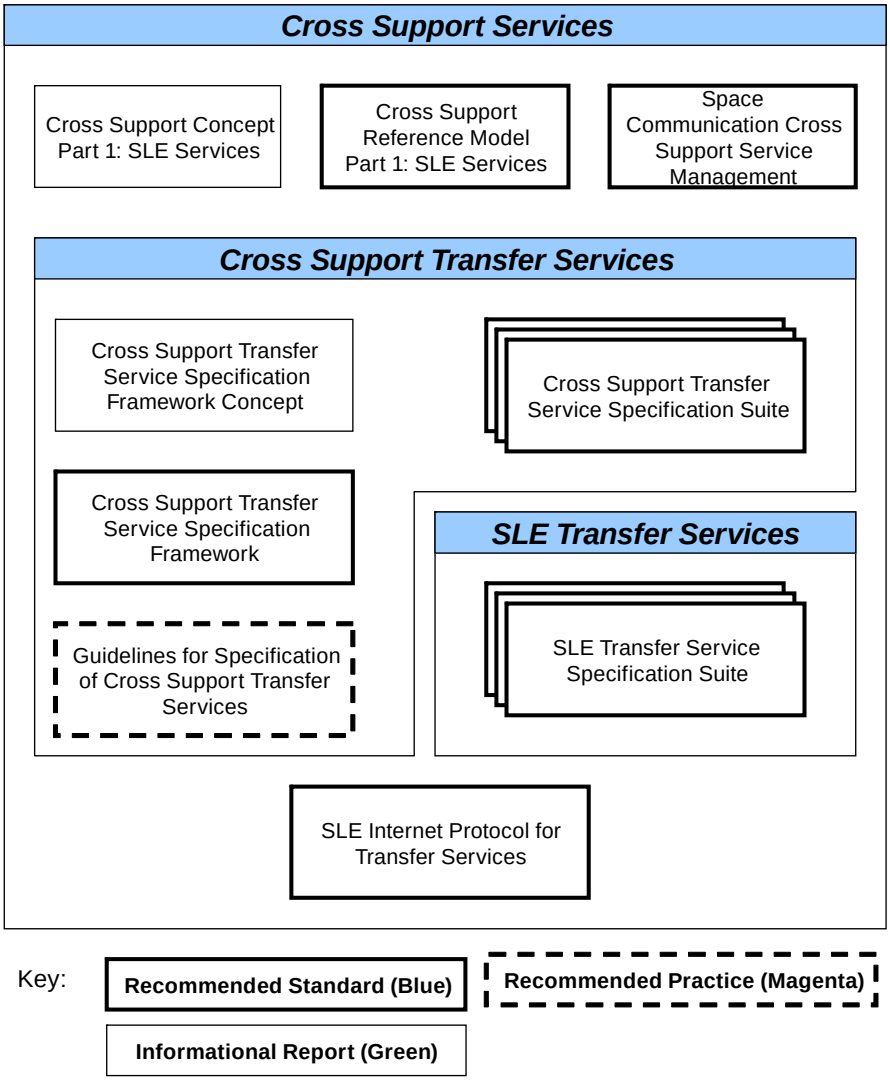

Figure 1-1: Cross Support Service Documentation

The Cross Support Services documents that are related to Cross Support Transfer Services are:

a) *Cross Support Concept—Part 1: Space Link Extension Services* (reference [I2]): A report introducing the concepts of cross support and the SLE services. Many of the concepts for the SLE transfer services have been adopted for the CSTSes (see h) below).

b) *Cross Support Reference Model—Part 1: Space Link Extension Services* (reference [1]): A Recommended Standard that defines the framework and terminology for the specification of SLE services. Much of the framework and terminology of this reference model has been adopted or adapted for CSTSes (see 1.6.1.3 and 2.2).

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c) *Space Communication Cross Support Service Management* suite (references [I4], [I6] and [I7]. Future data format Recommended Standards will specify the Service Management Information Entities that are used to configure and schedule CSTSes.

d) The *SLE Transfer Services suite*: The SLE Transfer Services are a suite of Cross Support Services that are used to transfer specific telecommand and telemetry protocol data units. The SLE Transfer Services are closely related to the CSTS suite in that they collectively define the set of operations that are the basis for the CSTS Specification Framework. However, because of history (the SLE Transfer Services were already specified and implemented prior to development of the CSTS Specification Framework) the SLE Transfer Services are separated from CSTSes.

e) *Space Link Extension—Internet Protocol for Transfer Services* (reference [2]): A Recommended Standard that defines a protocol for transfer of PDUs defined in the Cross Support Transfer Services. This Recommended Standard was originally developed to support SLE transfer services (hence the title), but it is also applicable to use by Cross Support Transfer Services.

The documents specific to Cross Support Transfer Services are:

f) *Cross Support Transfer Services Specification Framework* (this Recommended Standard): A Recommended Standard that defines the specification of the Cross Support Transfer Service procedures;

g) *Guideline for Specification of Cross Support Transfer Services* (reference [I3]): A Recommended Practice that defines the guidelines for construction of a Cross Support Transfer Service based on the CSTS Specification Framework;

h) *Cross Support Transfer Services Specification Framework Concept* (reference [I5]): A Report that provides tutorial material on the objectives and concepts of the CSTS Specification Framework;

i) *Cross Support Transfer Services Suite*: The set of specifications for actual CSTSes built from the procedures in the CSTS Specification Framework and in accordance with the CSTS Guidelines.

1.6 DEFINITIONS, NOMENCLATURE AND CONVENTIONS

1.6.1 DEFINITIONS

1.6.1.1 Definitions from Open Systems Interconnection (OSI) Basic Reference Model

This Recommended Standard makes use of a number of terms defined in reference [3]. The use of those terms in this Recommended Standard shall be understood in a generic sense, i.e., in the sense that those terms are generally applicable to technologies that provide for the exchange of information between real systems. Those terms are:

a) abstract syntax;

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b) application entity;

c) application layer;

d) flow control;

e) real system.

1.6.1.2 Definitions from Abstract Syntax Notation One

This Recommended Standard makes use of the following terms defined in reference [4]:

a) Abstract Syntax Notation One (ASN.1);

b) Object Identifier;

c) (data) type;

d) (data) value.

NOTE – In annex F of this Recommended Standard, ASN.1 is used for specifying the abstract syntax of service operation invocations and responses.

1.6.1.3 Definitions from Cross Support Reference Model

This Recommended Standard makes use of the following terms defined in reference [1]:

a) binding;

b) initiator;

c) invoker;

d) operation;

e) performer;

f) physical channel;

g) responder;

h) service agreement;

i) service provider;

j) service user;

k) space link.

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1.6.1.4 Definitions from CCSDS SANA Registry Management Policy

This Recommended Standard makes use of the following terms defined in reference [6]:

a) OID Registry;

b) owned by Agencies;

c) owned by xxx Area;

d) Review Authority;

e) Service Site and Aperture Registry;

f) Spacecraft Registry.

1.6.1.5 Definitions from SANA Role, Responsibilities, Policies, and Procedures

This Recommended Standard makes use of the following terms defined in reference [7]:

a) delegation;

b) registration rules;

c) registry;

d) SANA Steering Group.

1.6.1.6 Additional Definitions

1.6.1.6.1 acknowledgement: A confirmation that the invocation sent by the invoker was accepted by the performer and will now be acted upon.

a) An acknowledgement with a negative result is also called a negative acknowledgement.

b) An acknowledgement with a positive result is also called a positive acknowledgement.

1.6.1.6.2 association: A cooperative relationship between a service-providing application entity and a service-using application entity. An association is formed by exchanging service protocol data units using an underlying communications service.

1.6.1.6.3 communications service: A capability that enables a CSTS-providing application entity and a CSTS-using application entity to exchange information.

1.6.1.6.4 confirmed operation: An operation that requires the performer to return a report of the operation outcome to the invoker. Confirmed operations are further classified as two-phase operations and three-phase operations.

1.6.1.6.5 Cross Support Complex: A set of resources that are operated by a single management authority to provide Cross Support Services to a space flight mission.

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1.6.1.6.6 Cross Support Complex Management: The authority that negotiates the provision of service packages with Cross Support Utilization Management and controls and monitors the production and provision of the Cross Support Transfer Service instances by the Functional Resources belonging to the Cross Support Complex.

1.6.1.6.7 Cross Support Service: A set of capabilities that an object that belongs to one Space Agency provides to objects that belong to other Space Agencies by means of one or more ports, in support of spacecraft operations. A Cross Support Service can also be used within a given Space Agency.

1.6.1.6.8 Cross Support Transfer Service (CSTS): A subclass of Cross Support Service that provides reliable, access-controlled transfer of spaceflight mission-related data between ground element entities, realized through the invocation and performance of defined operations in accordance with defined procedures. A CSTS is qualified by the kind of data it transfers (e.g., telemetry frames, tracking data). A CSTS may optionally have capabilities to coordinate and observe the behavior of the production with which this service is associated.

1.6.1.6.9 Cross Support Transfer Service instance: An instance of a specific Cross Support Transfer Service type by means of which a Cross Support Complex provides the capability to the service user to transfer the service-type specific spaceflight mission-related data.

1.6.1.6.10 Cross Support Service production: Performing of the data acquisition process and/or the data transformation as necessary for the given type of Cross Support Transfer Service.

1.6.1.6.11 Cross Support Utilization Management: The abstraction of the entities within a real ground system that on behalf of the cross supported mission interacts with the Cross Support Complex Management to arrange for the required Cross Support Services.

1.6.1.6.12 Cross Support Service provision: Exposing the operations necessary so that the service user can obtain the service. Provision involves the interface between the service user and the service provider.

1.6.1.6.13 data acquisition process: The means by which a Cross Support Complex provides the capability to a service provider to access data required for service provisioning or to access information coming from service production (e.g., physical channel of the space link).

1.6.1.6.14 derivation: A mechanism that allows extending (see 1.6.1.6.20) or refining (see 1.6.1.6.44) an operation or the behavior of a procedure.

NOTE – Derivation can also be applied to a Cross Support Transfer Service.

1.6.1.6.15 Directive Identifier: In the context of a CSTS, the unique identifier of a directive defined for service provision or service production. A Directive Identifier is defined as a Published Identifier (see D6).

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1.6.1.6.16 Directive Name: A data structure consisting of a Directive Identifier that represents an individual directive type, and a Functional Resource Name that represents the Functional Resource with which the specific instance of that directive type is associated.

1.6.1.6.17 Event Identifier: In the context of a CSTS, the unique identifier of an event defined for service provision or service production. An Event Identifier is defined as a Published Identifier (see D6).

1.6.1.6.18 Event Label: (See E8 for the detailed definition.)

1.6.1.6.19 Event Name: (See E5 for the detailed definition.)

1.6.1.6.20 extension: The act of extending operations or procedures. Operations are extended by a) adding new parameters to the invocation or response message or b) extending the range of values for already existing parameters or c) changing an unconfirmed operation into a confirmed operation. Procedures are extended by a) adding new operations or b) extending the used operations.

1.6.1.6.21 Framework: A set of generic behaviors (called common procedures) and the constituent common operations used to simplify the specification of systems providing or using CSTSes.

1.6.1.6.22 Functional Resource Instance: An instance of a Functional Resource Type.

1.6.1.6.23 Functional Resource Instance Number: An integer index used to identify an instance of a Functional Resource Type.

1.6.1.6.24 Functional Resource Name: The unique identifier of an instance of a Functional Resource. A Functional Resource Name is made of a Functional Resource Type and a Functional Resource Instance Number.

1.6.1.6.25 Functional Resource Type: A logical function or related set of functions that characterizes a unique instance of service provider or production capability. A Functional Resource Type is defined as a Published Identifier (see D6).

1.6.1.6.26 invocation: The making of a request by an entity (the invoker) to another entity (the performer) to carry out the invoked operation.

1.6.1.6.27 Label List: A data structure that specifies the name of a list of Parameter Labels or Event Labels, indicates if the given list is the default list, and contains all Parameter Labels or Event Labels represented by that Label List name.

1.6.1.6.28 Label List Set: The set of Label Lists accessible by the user of the given service instance.

1.6.1.6.29 object: A functional entity that interacts with other objects. Objects are of different types, which determine their function and behavior. Objects are characterized by their interfaces, which are called ports. One object may provide multiple ports.

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1.6.1.6.30 operation: A task that the invoker requests the performer to execute. Depending on the type of operation, the performer may or may not report the result of the operation to the invoker. Service user and service provider interact by invoking and performing operations.

1.6.1.6.31 parameter: In the context of an operation, data that may accompany the operation's invocation, acknowledgement, or return.

NOTE – The term parameter is also used to refer to mission-dependent configuration information used in the production or provision of the service.

1.6.1.6.32 Parameter Identifier: In the context of a CSTS, the unique identifier of a parameter type defined for service provision or service production. A Parameter Identifier is defined as a Published Identifier (see D6).

1.6.1.6.33 Parameter Label: (See E7 for the detailed definition.)

1.6.1.6.34 Parameter Name: (See E4 for the detailed definition.)

1.6.1.6.35 performance: In the context of an operation, the carrying out of the operation by an object (the performer).

1.6.1.6.36 port identifier: Identifier of a source or a destination in a communications system.

NOTE – For purposes of the communications mapping, the endpoints of a CSTS association are identified by port identifiers, namely, an 'initiator port identifier' and a 'responder port identifier'. The port identifiers represent all the technology-specific addressing information needed to establish communications between service user and service provider and to route CSTS PDUs between them.

1.6.1.6.37 procedure: A specified series of actions performed using operations which have to be executed in order to implement a specified behavior.

1.6.1.6.38 procedure configuration parameter: A configuration parameter for a procedure type. If a service permits multiple instances of a procedure type, each such procedure instance will have its own instances of (and values for) the procedure configuration parameters for that procedure type. Unless explicitly specified otherwise in the Framework definition of a procedure type, the method(s) by which the values of the procedure configuration parameters are set is (are) delegated to the service using the procedure or to a derived procedure which may delegate setting of procedure configuration to service management (see 1.6.1.6.49 and 2.3). Some procedure configuration parameters may be dynamically modifiable (see 1.6.3.2.6). Dynamic modification of procedure configuration parameter values is performed by the user of the service that uses that procedure. Unless explicitly specified otherwise in the Framework definition of a procedure type, the method(s) by which the values of dynamically modifiable procedure configuration parameters are modified is (are) delegated to the service using the procedure or to a derived procedure.

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NOTE – The method a service may use to set the value of dynamically modifiable procedure configuration parameters is the THROW-EVENT procedure (see 4.12). A derived procedure may comprise the EXECUTE-DIRECTIVE operation (see 3.13) as the method to set dynamically modifiable procedure configuration parameter values.

1.6.1.6.39 production status: The aggregate status of the production processes that generate or process the data that is transferred by the transfer service instance.

1.6.1.6.40 protocol abort: A communications failure event.

NOTE – In case of communications disruption, the underlying communications service will report a communications failure event to the application. Occurrence of the communications failure event is referred to as a 'protocol abort'.

1.6.1.6.41 Published Identifier: A unique identifier that allows identification of a spacecraft, a facility where a CSTS provider is located, a Functional Resource Type, procedure type, a parameter, a directive, or an event. Published Identifiers are allocated by the Space Assigned Numbers Authority (SANA) and registered in standard SANA registries for use in CCSDS services and protocols, including but not limited to CSTSes.

1.6.1.6.42 real-time data: Data that can be accessed by the service user as soon as it is collected or generated by the service provider.

1.6.1.6.43 recorded data: Data that has been collected and stored by the service provider for access by the service user at some later time.

1.6.1.6.44 refinement: The act of refining operations or procedures. Operations are refined by constraining the values of parameters or by detailing the parameter semantics. Procedures are refined by modifying, e.g., narrowing, their semantics or defining their behavior or states in more detail.

1.6.1.6.45 registered parameter: A parameter that has been assigned a Published Identifier that is registered with SANA as specified in more detail in annex E.

1.6.1.6.46 response: A report, from the performer to the invoker:

a) of the acceptance of the invocation sent by the invoker; such response is referred to as acknowledgement; or

b) of the outcome of the performance of the invoked operation; such report is referred to as return.

1.6.1.6.47 return: A report, from the performer to the invoker, of the outcome of the performance of the operation.

a) A return with a negative result is also called a negative return.

b) A return with a positive result is also called a positive return.

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1.6.1.6.48 service instance provision period: The time during which a service is scheduled to be provided by this instance.

1.6.1.6.49 service management parameter: A configuration parameter of a CSTS for which the initial value is set by Service Management methods, e.g., through a Utilization Request (see reference [I6]). Some CSTS configuration parameters are explicitly defined to be service management parameters by this Recommended Standard. In addition, a service using a procedure or a derived procedure may specify some or all of the procedure configuration parameters (see 1.6.3.2.6) of that (derived) procedure to be service management parameters. For each procedure configuration parameter that the service using the procedure/derived procedure specifies as being a service management parameter, Service Management will set one value for that procedure configuration parameter, which will apply to every instance of that (derived) procedure.

1.6.1.6.50 service package: The set of Cross Support Transfer Service instances, which may be of different service types, together with the specification of the characteristics of the production of those Cross Support Transfer Service instances that are provided by one Complex to one or more service users as agreed between Complex Management and Utilization Management.

1.6.1.6.51 started procedure: A procedure placed in the 'active' substate by a successful START operation.

NOTE – 'started' applies to a stateful CSTS procedure that has START and STOP operations. A started procedure is placed in the 'active' substate by a successful START operation and remains active until the procedure is (a) placed in the 'inactive' substate by a successful STOP operation, (b) terminated in response to a protocol error, or (c) terminated by the Association Control procedure.

1.6.1.6.52 stateful procedure: A procedure with two substates: 'inactive' and 'active'.

1.6.1.6.53 stateless procedure: A procedure without substates.

1.6.1.6.54 three-phase operation: An operation that requires the performer to return to the invoker an initial acknowledgement of the acceptance of the invocation in addition to the report of the execution of the operation.

1.6.1.6.55 two-phase operation: An operation that requires the performer to return to the invoker the report of the execution of the operation.

1.6.1.6.56 unconfirmed operation: An operation for which the performer does not return a report of its outcome to the invoker.

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1.6.2 NOMENCLATURE

1.6.2.1 Normative Text

The following conventions apply for the normative specifications in this Recommended Standard:

a) the words 'shall' and 'must' imply a binding and verifiable specification;

b) the word 'should' implies an optional, but desirable, specification;

c) the word 'may' implies an optional specification;

d) the words 'is', 'are', and 'will' imply statements of fact.

NOTE – These conventions do not imply constraints on diction in text that is clearly informative in nature.

1.6.2.2 Informative Text

In the normative sections of this document, informative text is set off from the normative specifications either in notes or under one of the following subsection headings:

– Overview;

– Background;

– Rationale;

– Discussion.

1.6.3 CONVENTIONS

1.6.3.1 Specification of Operations

1.6.3.1.1 General

Section 3 of this Recommended Standard specifies the common operations that can be used by CSTSes. The specification of each operation is divided into subsections as described in 1.6.3.1.2 and 1.6.3.1.3.

1.6.3.1.2 Behavior Subsection

The Behavior subsection provides a brief description of the operation. Additionally, it indicates whether the operation may be invoked by the service user, service provider, or both; and whether there are any constraints on when the operation may be invoked.

NOTE – Whether the operation is confirmed, unconfirmed, or acknowledged is specified in the title of the section specifying the operation.

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1.6.3.1.3 Invocation, Response, and Parameters Subsection

The Invocation, Response, and Parameters subsection describes the parameters associated with each operation, including their semantics. A table accompanying the description of each operation lists all parameters associated with the operation and, for the invocation, the acknowledgement (if applicable) and the return, whether the parameter is always present, always absent, or conditionally present.

For parameters that are conditionally present, the parameter description specifies the conditions for the presence or absence of the parameter. The condition is generally based on the value of another parameter in the same invocation, acknowledgement, or return; for example, in the return of an operation, the `diagnostic` parameter is present if and only if the value of the `result` parameter is 'negative'. For a conditional parameter in a return, the condition may be based on the value of a parameter in the corresponding invocation.

In the table, the following convention is used to indicate whether a parameter is always present, always absent, or conditionally present:

a) M Mandatory, i.e., always present;

b) C Conditionally present;

c) Blank Always absent.

NOTE – Even though a parameter is characterized as always present, its description may specify that its value may be left unspecified. Given that in ASN.1 a parameter value not set to a specific value is mapped to the NULL type (see annex F), this by convention in this document is expressed as this parameter having the value 'null'.

1.6.3.2 Specification of Procedures

1.6.3.2.1 General

Section 4 of this Recommended Standard specifies the procedures that can be used by CSTSes. The specification of each procedure is divided into subsections as described in 1.6.3.2.2 through 1.6.3.2.6.

Each procedure section follows a common template covering a descriptive and a prescriptive part.

1.6.3.2.2 Version Number Subsection

The version number of the procedure is identified in the Version Number subsection and is used by the service using that procedure.

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1.6.3.2.3 Discussion Subsection

The descriptive part covers the purpose and the concept of the procedure. This part provides the reader with an overview of the procedure.

1.6.3.2.4 Behavior Subsection

The prescriptive part introduces the sequence of activities that describes the behavior of the procedure, e.g., starting, running, and ending the activities. The operations required by the procedure are listed, and for each of them the procedure identifies those operations that are extended and/or refined by the procedure. For those operations that require extension or refinement, the details are provided. For those operations that do not require extension or refinement, the operations are not repeated as they fully conform to the common definition of the common operations (see section 3) or to the specification of the procedure from which the described procedure is derived (e.g., the Cyclic Report procedure is derived from the Unbuffered Data Delivery procedure).

The prescriptive part ends with the service provider state transition table applicable to the procedure.

1.6.3.2.5 Required Operations Subsection

This Required Operations subsection identifies the operations used by the procedure.

1.6.3.2.6 Configuration Parameters Subsection

This Configuration Parameters subsection lists the parameters that need to be configured in the context of this procedure.

This subsection also identifies those parameters that may be accessed (read) by the service user of any service that includes a procedure that contains a GET operation. For each configuration parameter, this subsection provides cross references to the use of the parameter in the specification of the procedure and also identifies the Parameter Identifier to be used in reporting the value of the parameter (see 1.6.1.6.34).

Furthermore, this subsection specifies which, if any, of the configuration parameter values may be dynamically modified while the service that is executing the procedure is bound. If one or more configuration parameters are dynamically modifiable, the subsection identifies the event that is used to notify (by means of the NOTIFY operation) when such a modification has occurred.

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1.6.3.2.7 Procedure State Table Subsection

Each stateful procedure is complemented with a state transition table describing the behavior of the service provider implementing the procedure. The state tables follow the following rules:

a) The state tables specify operation interactions and state transitions for the procedures on the service provider side in its role as either invoker or performer.

b) The leftmost column simply numbers the rows of the table.

c) The second column of the state table lists all incoming events. Where these events correspond to the arrival of an incoming PDU, the ASN.1 type defined for this PDU in annex F is indicated in parentheses (( )).

d) Where an event is internal to the service provider, its description is put in single quotation marks (‘ ’).

e) The following columns (one column per state) on the right side of the table specify the behavior the service provider will exhibit, which depends on the current state and the incoming event. In some cases, the behavior additionally depends on Boolean conditions, also referred to as predicates. Such conditions are put in double quotation marks (“ ”). The predicates are defined in a table following the procedure state table. Predicates that are simple Boolean variables set only by that state machine itself are referred to as Boolean flags. The dependency on a predicate is presented in form of an IF <condition> THEN <action> [[ELSEIF <condition> THEN <action>] ELSE <action>] ENDIF clause.

f) If the action given in the table is simply to send a specific PDU, that is indicated by the appearance of the name of ASN.1 type of the PDU to be sent in parentheses (( )). If that PDU is a return or an acknowledgement, the name may be preceded by the plus symbol (‘+’) to indicate that `result` is ‘positive’ or by the negative symbol (‘−’) to indicate that `result` is ‘negative’. Where several actions are to be taken (referred to as a ‘compound action’), the name of the compound action is put in curly braces ({ }). The individual actions making up each compound action are identified in a table following the procedure state table. Where a simple action is to be taken, the name of the action is put in single quotes (‘ ’).

g) ‘Not applicable’ is stated where the given event can only occur in the given state because of an implementation error on the service provider side.

h) Where the consequences of an incoming event are not visible to the service user because the service provider does not send any PDU in reaction to the given event, the action is put in square brackets ([ ]).

i) State transitions are indicated by an arrow and the number of the state that will be entered; for example, ‘→ 1’ indicates the transition to state 1.

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j) The actions to be taken and the state transition are considered to be one atomic action. The sequence in which the actions shown in the table are executed is irrelevant except that the sending of PDUs shall be performed in the sequence stated in the table.

k) Whenever the service user invokes a confirmed operation with `invoke-id` set to <n>, it starts an associated return <n> timer. Should this timer expire before the return <n> is received, the service user invokes PEER-ABORT.

l) Whenever a procedure is derived from another procedure (also called parent procedure), the following applies:

   1) the derived procedure's state table contains the same incoming events as the parent procedure and may have additional ones;

   2) whenever the behavior in a given state and for an incoming event is fully identical to that of the parent procedure, its description is limited to a reference to the parent procedure's state table;

   3) whenever the behavior in a given state and for an incoming event is not fully identical to that of the parent procedure,

      – the behavior copied from the parent procedure is written in italic typeface; and

      – the behavior specific to the derived procedure is written in plain text.

1.6.3.3 Typographic Conventions

1.6.3.3.1 Operation Names

Names of service operations appear in uppercase.

1.6.3.3.2 Procedure Names

The names of procedures appear with initial capital letters (e.g., Buffered Data Delivery).

1.6.3.3.3 Parameter Names

In the main text, names of parameters of service operations generally appear in lowercase and are typeset in a fixed-width font (e.g., `responder-port-identifier`). The same convention is applied to parameters that are not service operation parameters, but are elements of a complex type parameter that is a service operation parameter. In annex F, the corresponding name is formed by omitting any hyphens contained in the name and using mixed-case (e.g., `responderPortIdentifier`).

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1.6.3.3.4 Value Names

The values of many parameters discussed in this Recommended Standard are represented by names. In the main text, those names are shown in quotation marks (e.g., 'no such service instance'). The corresponding name in annex F is formed by omitting any hyphens or white space contained in the name and using mixed-case (e.g., `noSuchServiceInstance`). The actual value associated with the name is constrained by the type of the parameter taking on that value. Parameter types are specified in annex F of this Recommended Standard.

NOTE – The name of a value does not imply anything about its type. For example, the value 'no such service instance' has the appearance of a character string but might be assigned to a parameter whose type is 'integer'.

1.6.3.3.5 State Names

This Recommended Standard specifies the states of service providers. States may be referred to by number (e.g., state 2) or by name. State names are always shown in single quotation marks (e.g., 'active').

1.6.3.3.6 PDU Names

The names of PDUs appear in mixed-case (e.g., BindInvocation).

1.6.3.3.7 Data Type Definitions

Data type definitions are presented in annex F in the form of a set of ASN.1 modules. Regardless of the conventions used elsewhere in this Recommended Standard, the text of the ASN.1 modules is typeset entirely in a fixed-width font.

1.6.3.3.8 Normative Mechanism and Data Structure Names

The names of normative mechanisms and data structures appear with initial capital letters (e.g., Cross Support Transfer Service, Functional Resource Name, Published Identifier). Such mechanisms and data structures have defined roles in the functioning of operations and procedures.

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1.7 REFERENCES

The following publications contain provisions which, through reference in this text, constitute provisions of this document. At the time of publication, the editions indicated were valid. All publications are subject to revision, and users of this document are encouraged to investigate the possibility of applying the most recent editions of the publications indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS publications.

NOTE – A list of informative references is provided in annex I.

[1] *Cross Support Reference Model—Part 1: Space Link Extension Services*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 910.4-B-2. Washington, D.C.: CCSDS, October 2005.

[2] *Space Link Extension—Internet Protocol for Transfer Services*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 913.1-B-2. Washington, D.C.: CCSDS, September 2015.

[3] *Information Technology—Open Systems Interconnection—Basic Reference Model: The Basic Model*. 2nd ed. International Standard, ISO/IEC 7498-1:1994. Geneva: ISO, 1994.

[4] *Information Technology—Abstract Syntax Notation One (ASN.1): Specification of Basic Notation*. 4th ed. International Standard, ISO/IEC 8824-1:2008. Geneva: ISO, 2008.

[5] *Time Code Formats*. Issue 4. Recommendation for Space Data System Standards (Blue Book), CCSDS 301.0-B-4. Washington, D.C.: CCSDS, November 2010.

[6] *CCSDS SANA Registry Management Policy*. Issue 1. CCSDS Record (Yellow Book), CCSDS 313.1-Y-1. Washington, D.C.: CCSDS, May 2016.

[7] *Space Assigned Numbers Authority (SANA)—Role, Responsibilities, Policies, and Procedures*. Issue 2. CCSDS Record (Yellow Book), CCSDS 313.0-Y-2. Washington, D.C.: CCSDS, May 2016.

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2 DESCRIPTION OF CROSS SUPPORT SERVICES

2.1 OVERVIEW

Cross Support Transfer Services (CSTSes) provide for reliable, access-controlled transfer of spaceflight mission related data between ground element entities. A Cross Support Service is characterized by the kind of data it transfers (e.g., telemetry data, tracking data, service production monitoring data), and therefore different CSTSes need to respond to specific requirements that may demand specific solutions. On the other hand, all CSTSes defined by CCSDS apply the same basic communications patterns in order to simplify specification, implementation, and operation of these services. The basic approach applied to CSTSes is that they are realized through invocation and performance of operations in accordance with well-defined procedures.

This Recommended Standard provides a Specification Framework for CSTSes with the objective to:

a) maximize the commonality between CCSDS CSTSes;

b) simplify specification of new CCSDS CSTSes; and

c) enable the design and implementation of reusable software components with the potential of simplifying the implementation of CSTSes.

NOTE – While this specification strives for enabling the design and implementation of reusable software components, it does not intend to provide a specification for such components.

This Recommended Standard defines basic building blocks from which services can be constructed. The companion Recommended Practice, *Guidelines for Specifications of Cross Support Transfer Services* (reference [I3]), defines the rules to be used for the specification of CSTSes.

Building blocks defined by the CSTS Specification Framework include:

a) data types for information exchanged between service user and service provider;

b) common operations that are invoked by one entity and performed by the other entity and as such implement the basic elements of interaction between service user and service provider; and

c) common procedures which define the behavior and protocol for the invocation and performance of a set of operations to achieve a well-defined objective.

A CSTS may be defined by combining a set of procedures specified in the CSTS Specification Framework in a manner that best suits the objective of the service.

To be generally applicable, parameters, operations, and procedures defined by the CSTS Specification Framework are sufficiently abstract that they may or may not be directly usable

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for real services. For cases where the building blocks are not directly usable, new operations or procedures can be derived from those defined in the CSTS Specification Framework.

Taking the concept of generic definitions one step further, this Recommended Standard supports the concept of abstract services (see reference [I5]) that specify the common operations and behavior of CSTSes but are not directly implementable because service-specific specifications are still missing. Real CSTSes can be derived from such abstract services.

NOTE – An example of an abstract service could be a CSTS Return Link Service from which real services such as CSTS RAF, CSTS RCF, and CSTS ROCF could be derived. These CSTSes would be equivalent to SLE RAF, SLE RCF, and SLE ROCF.

The relationships between the elements of the CSTS Specification Framework and example CSTSes based on the Framework are illustrated in figure 2-1.

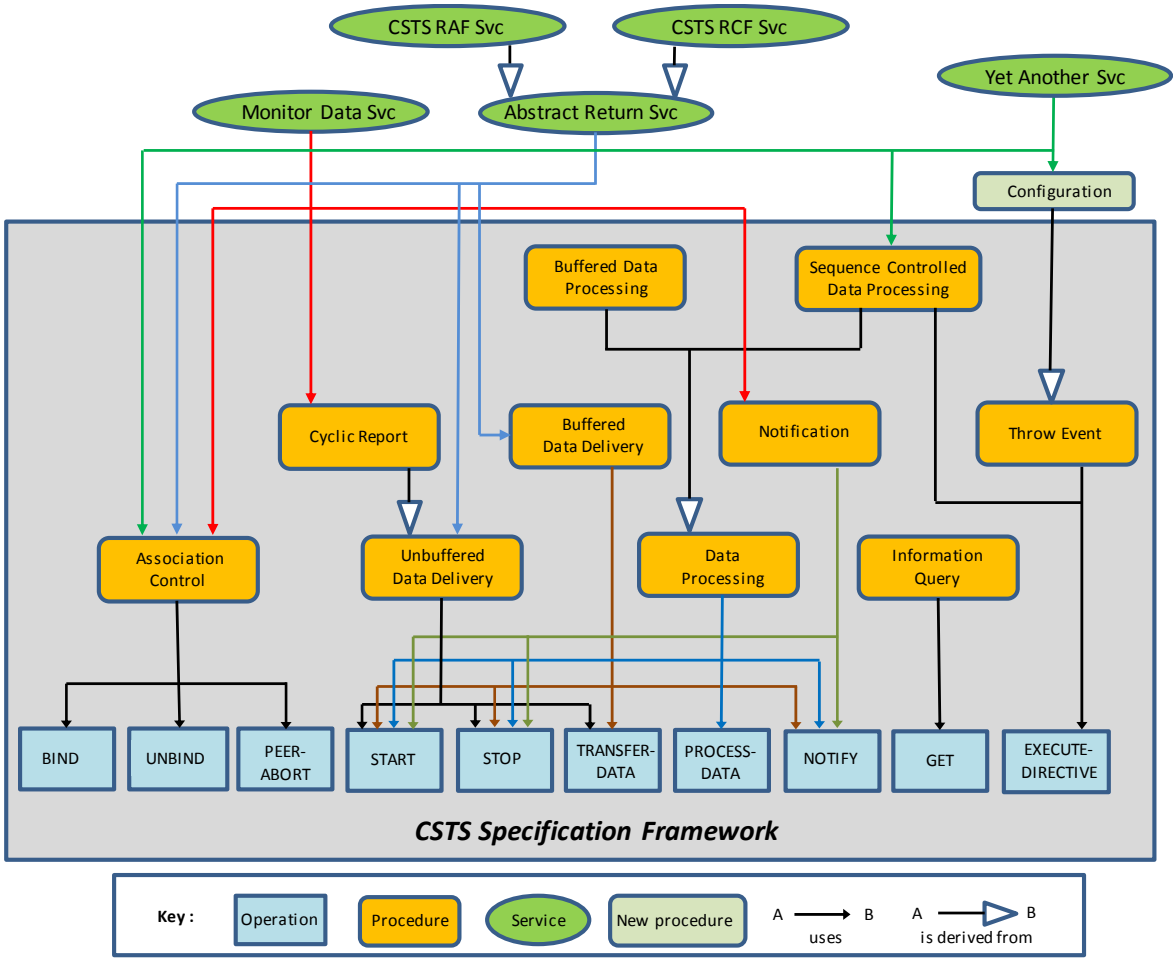

Figure 2-1: CSTS Specification Framework Concept

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2.2 CROSS SUPPORT REFERENCE MODEL

2.2.1 INTRODUCTION

CCSDS Cross Support Transfer Services are defined within a framework that is a logical extension of the Cross Support Reference Model (reference [1]) that was originally defined for Space Link Extension (SLE) services. The following subsections summarize concepts from the reference model that are supported by the CSTS Specification Framework and to which later sections in this Recommended Standard refer. Formal definitions of terms are provided in 1.6.

Before a Cross Support Transfer Service can be used, an association needs to be established between service user and service provider by binding the ports associated with the specific CSTS. To that end, the initiator issues the request to bind to the responder. If the responder can complete the binding, the required association is established and service user and service provider can invoke and perform the operations of the given CSTS type. Depending on the type of operation, the performer may or may not report the result of the operation to the invoker.

2.2.2 SERVICE PRODUCTION AND PROVISION

2.2.2.1 General

The Cross Support Reference Model (reference [1]) distinguishes between service production and service provision.

Cross Support Service production refers to the common processes performed by a Cross Support Complex associated with the provision of one or more Cross Support Services.

A Cross Support Complex is said to **provide** a service when it makes available to the service user the capability to obtain the service via one or more of its ports. Provision involves the interface between the service user and the service provider, and is characterized by the type(s) of data transferred and the quality of service with which they are transferred (e.g., completely, reliably, etc.).

The CSTS Specification Framework deals primarily with service provision. Service production is generally very specific for specific services or a class of services, and therefore the CSTS Specification Framework makes only very general assumptions on service production.

2.2.2.2 Service Production Status

The status of production resources is reported by means of the `resource-status` parameter of each of the associated Functional Resources except those Functional Resources that represent CSTS instances. The latter each have a `production-status` parameter. The CSTS specifies how the `production-status` value shall be determined based on the CSTS instance as such and on the `resource-status` parameters of the Functional

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Resource Instances involved in the service production. This Recommended Standard defines the permissible values of `production-status` and the transitions between these values in abstract terms (see annex B); these values may be refined by service specifications based on the CSTS Specification Framework. Service specifications may also define substates for one or more of the `production-status` values where appropriate.

Production status changes may be notified to the service user via any procedure that includes the NOTIFY operation (3.11), e.g., the Notification procedure (see 4.11). As for any other parameter, the current value of the `production-status` parameter may be obtained using (a) the Cyclic Report procedure defined in 4.10, if that is supported by the service, or (b) the GET operation, if any procedure of the service (including the Information Query procedure) uses the GET operation.

The `production-status` values and the permissible transitions, and the effects of these `production-status` values on common operations are defined in annex B.

2.3 SERVICE MANAGEMENT

For all CSTSes, service management determines the number and schedule of service instances to be provided, the resources required to enable those service instances, and the initial configuration of all service instances and their supporting resources. Configuration parameters that have their initial values set through Service Management are called service management parameters (see 1.6.1.6.49). Cross Support Service Management is the subject of separate CCSDS Recommended Standards (see references [I6] and [I7]).

Service management parameters may refer to service provision or to service production. Explicit specification of service management parameters in this Recommended Standard is confined to a small set of service provision parameters, including

a) identities of the service initiator (i.e., the service user) and the service responder (i.e., the service provider;

b) identity of the port at which the service is made available;

c) the service instance provision period.

For some procedures this Recommended Standard identifies procedure configuration parameters that are known to the service user and the service provider but the definition of how their values are determined is delegated to the service specification. The service specification may specify these values, or designate them to be service management parameters. Reference [I3] provides guidelines on how service management parameters shall be handled in derived service specifications.

For service management parameters that correspond to procedure configuration parameters, Service Management will configure all instances of a given procedure type being associated with a given service instance equally.

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Some procedure configuration parameters of individual procedure instances may be updated dynamically at any time while the service instance executing the procedure instances is bound. The dynamic modification of such procedure configuration parameters is outside the scope of Service Management and must be carried out within the CSTS instance itself, e.g., through a Throw Event procedure that is part of that service. The particular method(s) by which dynamic modifications of procedure configuration parameters are performed is left to the definition of the services that use such dynamically modifiable procedure configurations.

2.4 ELEMENTS OF THE CSTS SPECIFICATION FRAMEWORK

2.4.1 COMMON OPERATIONS

An operation is a task that the invoker requests the performer to execute and as such presents the basic interaction pattern between the service user and the service provider. The invocation of an operation may include parameters that specify further details of the task to be performed.

Operations are further classified by the number of interactions required to complete the operation:

a) An **unconfirmed operation** is invoked by the invoker and performed by the performer, but there is no report on the outcome of the operation.

b) For a **confirmed operation** the performer provides a report (the '**return**') to the invoker on success or failure of the operation. Operation returns comprise an indication of success (`result` has the value 'positive') or failure (`result` has the value 'negative') and, in case of failure, a `diagnostic` that further specifies the reason for the failure. Confirmed operations are further classified as:

   1) **two-phase operations**, for which the performer returns a single report to the invoker;

   2) **three-phase operations**, for which the performer provides an initial response in the form of an **acknowledgement** when receiving the invocation and subsequently issues the return when the operation has completed. This type of operation is typically used for operations where the task to be performed requires non-negligible time to complete. The acknowledgement confirms that the invocation has been received and understood and that the general preconditions for the operation are fulfilled.

NOTE – In labeling confirmed operations, the designation (CONFIRMED) identifies a two-phase confirmed operation, and (ACKNOWLEDGED) identifies a three-phase confirmed operation.

Confirmed operations are further classified as **blocking** or **non-blocking** with respect to the procedure that uses the operation. When a blocking operation has been invoked, no further operation of the same procedure instance can be invoked before the return to the invocation

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has been received. Non-blocking operations do not impose any constraints with respect to invocation of further operations.

The CSTS Specification Framework defines standard operation headers for unconfirmed and confirmed operations and a set of common operations for use within CSTS. To be of general use, the operations of the CSTS Specification Framework are rather abstract and might not all be directly usable within a procedure used by a specific CSTS. However, all operations used in a procedure of a CSTS that conforms to this Recommended Standard are derived directly or indirectly from the operations specified herein applying the rules described in 2.5.

The common operations defined by the CSTS Specification Framework are listed in table 2-1. Section 3 of this Recommended Standard provides the detailed specification of these operations.

Table 2-1: Common Operations Defined by the CSTS Specification Framework

Operation	Invoked By	Purpose	Confirmed	
			Ack.	Ret
BIND	service user	Establishment of an association with the peer.	No	Yes
UNBIND	service user	Release of an association previously established by a BIND operation.	No	Yes
PEER-ABORT	service user or service provider	Notification to the peer that the local application detected an error that requires the association to be terminated.	No	No
START	service user	Request that the service provider start performing activities associated with the procedure using the operation.	No	Yes
STOP	service user	Request that the service provider stop performing activities associated with the procedure using the operation.	No	Yes
TRANSFER-DATA	service provider	Transfer of a data unit to the service user.	No	No
PROCESS-DATA	service user	Request that the service provider process the data received.	No	No/ Yes (see NOTE)
NOTIFY	service provider	Sending of a notification of an event to a service user.	No	No
GET	service user	Ascertainment of the value of (a) service parameter(s).	No	Yes
EXECUTE-DIRECTIVE	service user	Request that the service provider perform a predefined action.	Yes	Yes

NOTE – For the PROCESS-DATA operation, both an unconfirmed and a confirmed variant exist. It is at the discretion of the procedure using this operation to specify if the unconfirmed or confirmed variant is used.

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2.4.2 COMMON PROCEDURES

Procedures define the protocol and the expected behavior for the invocation and performance of a set of operations to achieve a well-defined objective. A CSTS may be specified by assembling a given set of procedures to handle specific aspects of the service.

For instance, a service that forwards telemetry received on the space link can be broken down into a number of procedures that handle association establishment and release, actual transfer of telemetry data units, status reporting, and querying of the service configuration parameters. All of these procedures except for telemetry data transfer can also be used for a service that supports reception and radiation of telecommands, where only a subset of the parameters in the reports differs.

The specification of a procedure includes:

a) a description of the objective of the procedure including all assumptions that are made with respect to the type of data to be transferred and the service production process (descriptive);

b) a definition of the behavior of this procedure (prescriptive);

c) a definition of the operations that constitute this procedure (prescriptive);

d) a description of behavior expected of the service provider and the service user supported by a service provider side state matrix, where applicable (prescriptive).

As far as the protocol is concerned, procedures can be stateful or stateless. A stateful procedure supports the states 'inactive' and 'active' with transitions between these states triggered by well-defined operation invocations or responses. Typically the transition from 'inactive' to 'active' is triggered by a START invocation and the transition from 'active' to 'inactive' is triggered by a STOP return. However, other transitions may exist. For instance, procedures using three-phase operations might transition from 'inactive' to 'active' with the operation invocation and back to 'inactive' with the final return.

NOTE – The Association Control procedure is an exception to the above rules. The Association Control procedure does not belong to any class (stateful or stateless) and is required to manage the association.

A CSTS will typically use more than one procedure in addition to the Association Control procedure and may require more than one procedure of the same type to be active at the same time, e.g., to transfer different data streams concurrently. Therefore this Recommended Standard distinguishes between the **procedure type** and the **procedure instance**. The procedure type corresponds to the specification of the procedure or the supporting program that implements the procedure specification. A procedure of a given type can be instantiated once or several times as part of the instantiation of the service using this procedure. Different instances of the procedure are distinguished by a 'procedure instance identifier' that is assigned by service management when creating the service package and included in all operation invocation and response headers.

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NOTE – Further information on how a service uses predefined procedures is provided in 2.5. Normative rules for this purpose are specified in reference [I3].

The CSTS Specification Framework defines a set of common procedures that cover typical tasks of a CSTS. In order to be commonly usable, the procedure definition and in particular the purpose and semantics specification are reasonably abstract, such that the specifications as provided by this Recommended Standard may sometimes not be directly usable. For those cases, reference [I3] specifies methods to derive more specific procedures from these common procedures.

Table 2-2 identifies the common procedures included in this CSTS Specification Framework and table 2-3 shows the operations that are used by these procedures. Section 4 of this Recommended Standard provides the detailed specification of these procedures.

Table 2-2: Common Procedures Defined by the CSTS Specification Framework

Procedure	Purpose	Class
Association Control	Establishment and release of an association between a service user and a service provider.	N/A
Unbuffered Data Delivery	Best effort transfer of bulk data, structured into data units, sent from the service provider to the service user in real-time delivery mode.	SF
Buffered Data Delivery	In-sequence transfer of bulk data, structured into data units, sent from the service provider to the service user. In real-time mode, low latency is given priority over data completeness. In complete mode, data completeness is given priority over low latency.	SF
Data Processing	Processing of individual data units in the sequence as sent by the service user to the service provider and reporting of processing progress.	SF
Buffered Data Processing	Processing of data units contained in buffers in the sequence as sent by the service user to the service provider and reporting of processing progress. Processing may be in complete mode at the expense of latency or in timely mode at the expense of data loss.	SF
Sequence-Controlled Data Processing	Processing with full flow control of individual data units in the sequence as sent by the service user to the service provider and reporting of processing progress.	SF
Information Query	Query by the service user of the value of one or more parameters related to the service provider or service production behavior.	SL
Cyclic Report	Periodic reporting of parameter values from the service provider to the service user.	SF
Notification	Notification of the service user by the service provider of events of interest to the service user.	SF
Throw Event	Signaling to the service provider the occurrence of an event requiring a configuration change action and report of the result of the action back to the service user.	SF
NOTE – 'SF' and 'SL' indicate 'stateful' and 'stateless', respectively.		

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Table 2-3: Use of Operations by Common Procedures

	Association Control	Unbuffered Data Delivery	Buffered Data Delivery	Data Processing	Buffered Data Processing	Sequence-controlled Data Processing	Information Query	Cyclic Report	Notification	Throw Event
BIND	B									
UNBIND	B									
PEER-ABORT	NB									
START		B	B	B	B	B		B	B	
STOP		B	B	B	B	B		B	B	
TRANSFER-DATA		NB	NB					NB		
PROCESS-DATA				NB	NB	NB				
GET							NB			
NOTIFY			NB	NB	NB	NB			NB	
EXECUTE-DIRECTIVE						NB				NB
NOTE – 'B' and 'NB' indicate that the operation is 'Blocking' or 'Non-Blocking', respectively.										

2.5 PRINCIPLES OF USING THE CSTS SPECIFICATION FRAMEWORK

2.5.1 OVERVIEW

The CSTS Specification Framework provides a set of reusable building blocks for the specification of CSTSes and defines general rules by which such building blocks can be extended and refined to match the specific requirements of a CSTS.

The specification of a CSTS can be constructed by composition of procedures that either are fully predefined within the CSTS Specification Framework or are derived from those defined in the Framework. Specification of a completely new service-specific procedure using common operations or operations derived from the common operations is permissible but is not recommended.

The rules for derivation of operations and procedures have been rigorously applied to the specification of the CSTS Specification Framework itself:

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a) The common procedures specified in section 4 present the most abstract and general version; several procedures defined within the CSTS Specification Framework derive extended operations, which may be further derived by services using these procedures.

b) Some of the procedures defined within the CSTS Specification Framework are derived from more basic procedures also defined in the Framework. For instance, the Cyclic Report procedure is derived from the Unbuffered Data Delivery procedure.

The derivation rules can be further applied to operations and procedures that have been derived from the operations and procedures defined within the CSTS Specification Framework. It is envisaged that such operations and procedures might eventually be included in the Framework if they prove to be useful for more than one service type.

The normative specification of the rules for derivation of operations and procedures and for composition of services can be found in reference [I3]. The following subsections provide a brief summary.

2.5.2 DERIVATION OF OPERATIONS AND PROCEDURES

Derivation of operations and procedures from the building blocks defined in the CSTS Specification Framework encompasses two dimensions:

a) extension, by which new data or behavior are added to a specification; and

b) refinement, by which the range of values may be constrained or the semantics of parameters may be specialized.

Operations may be extended in the following ways:

a) New parameters may be added (syntax and semantics specification) to an operation invocation or response; unless explicitly specified otherwise, all operations defined in the CSTS Specification Framework can be extended in this way.

b) In some cases additional values may be defined for an existing parameter (e.g., additional diagnostics or additional types of notification).

c) In some cases, the format and content of a parameter may have to be specified by the service using the corresponding operation. This is necessary because, for some operations, there are parameters whose structure is unspecified.

Operations may be refined by narrowing the value range of a parameter or by specializing the meaning of a parameter. For instance, the `generation-time` parameter of the TRANSFER-DATA operation in the Buffered Data Delivery procedure may be refined for a procedure dealing with transfer of telemetry by stating that the `generation-time` is the Earth Receive Time of the telemetry frame being transferred.

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Procedures may be extended in the following ways:

a) extension of the operations used by a procedure as described above;

b) addition of operations defined in the CSTS Specification Framework or derived from operations defined in the Framework.

Procedures may be refined by narrowing the specification of the semantics associated with the procedure or by adding more detail to the behavior description or the state table. The refinement of a procedure does not imply the definition of a new procedure.

As an example, a Telemetry Delivery procedure could be derived from the Buffered Data Delivery procedure by extension and refinement of the operations START and TRANSFER DATA and by refinement of the semantics associated with the data to be transferred and the parameters of the operations. The extension of a procedure implies the definition of a new procedure (derived procedure).

2.5.3 SPECIFICATION OF SERVICES BY COMPOSITION OF PROCEDURES

A CSTS can be specified by composition of procedures defined in the CSTS Specification Framework, derived from procedures in the Framework or derived from an existing CSTS.

Every service includes the Association Control procedure (see 4.3). Only a single instance of the Association Control procedure exists throughout the lifetime of a transfer service instance.

In addition to the Association Control procedure a service may comprise any number of further procedure types and may use one or more instances of each procedure type. However, one single procedure instance is designated the **prime procedure** of the service. All other procedure instances are referred to as secondary procedures.

NOTE – The prime procedure (instance) can be of the same type as one or more secondary procedure instances.

The prime procedure (instance) of a service should reflect the primary purpose of the service. In practical terms it determines the state of the service and as such determines the orderly association release as detailed in 2.6.

2.6 PROTOCOL DESCRIPTION

2.6.1 STATES OF THE SERVICE PROVIDER

The service user and service provider of a Cross Support Transfer Service can interact as soon as the associated service ports are bound by establishment of an association between the service user and the service provider. Binding is achieved by the Association Control procedure that is included in every CSTS.

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Once the service instance is bound other procedures used by the service can be operated according to their specific protocol.

NOTE – This Recommended Standard does not specify any interdependencies between the procedures that constitute a service. However, the service specification may specify dependencies that must be observed, e.g., with respect to the sequence in which procedures are started.

When the service instance is bound the service state is further determined by the state of the prime procedure (instance). If the prime procedure is stateful the state 'bound' has two substates, 'ready' and 'active'. When the prime procedure is 'inactive', the service instance is in the state 'bound.ready', and when the prime procedure is 'active', the service instance is in the state 'bound.active'. If the prime procedure is stateless then the service state 'bound' has no substates.

A service instance having a stateful prime procedure can be unbound by the service user in an orderly manner only while in the state 'bound.ready', i.e., while the prime procedure is 'inactive'. Service instances with a stateless prime procedure can be unbound at any time. Finally a service instance may be aborted by either entity at any time by invoking the PEER-ABORT operation.

Any stateful secondary procedure has a state machine of its own but has no effect on the overall service instance state. This implies that the UNBIND operation can be invoked while one or more stateful secondary procedures are in the state 'active'. Therefore, for a stateful secondary procedure, unbinding has the same effect as PEER-ABORT.

Any stateless secondary procedure is unaffected by the overall service instance state. The operations of any stateless secondary procedure instance may be invoked whenever the service instance is in the 'bound.ready' or 'bound.active' state if the prime procedure of that service is stateful or the service instance is in the 'bound' state if the prime procedure of that service is stateless.

The overall relationship of the states of the service instance, the prime procedure, and secondary procedures is illustrated in figures 2-2 and 2-3 for a stateful and a stateless prime procedure, respectively.

NOTE – The diagrams in figures 2-2 and 2-3 do not present state diagrams in a formal sense, as they present different state machines in a synoptic view. The corresponding normative statements can be found in annex G.

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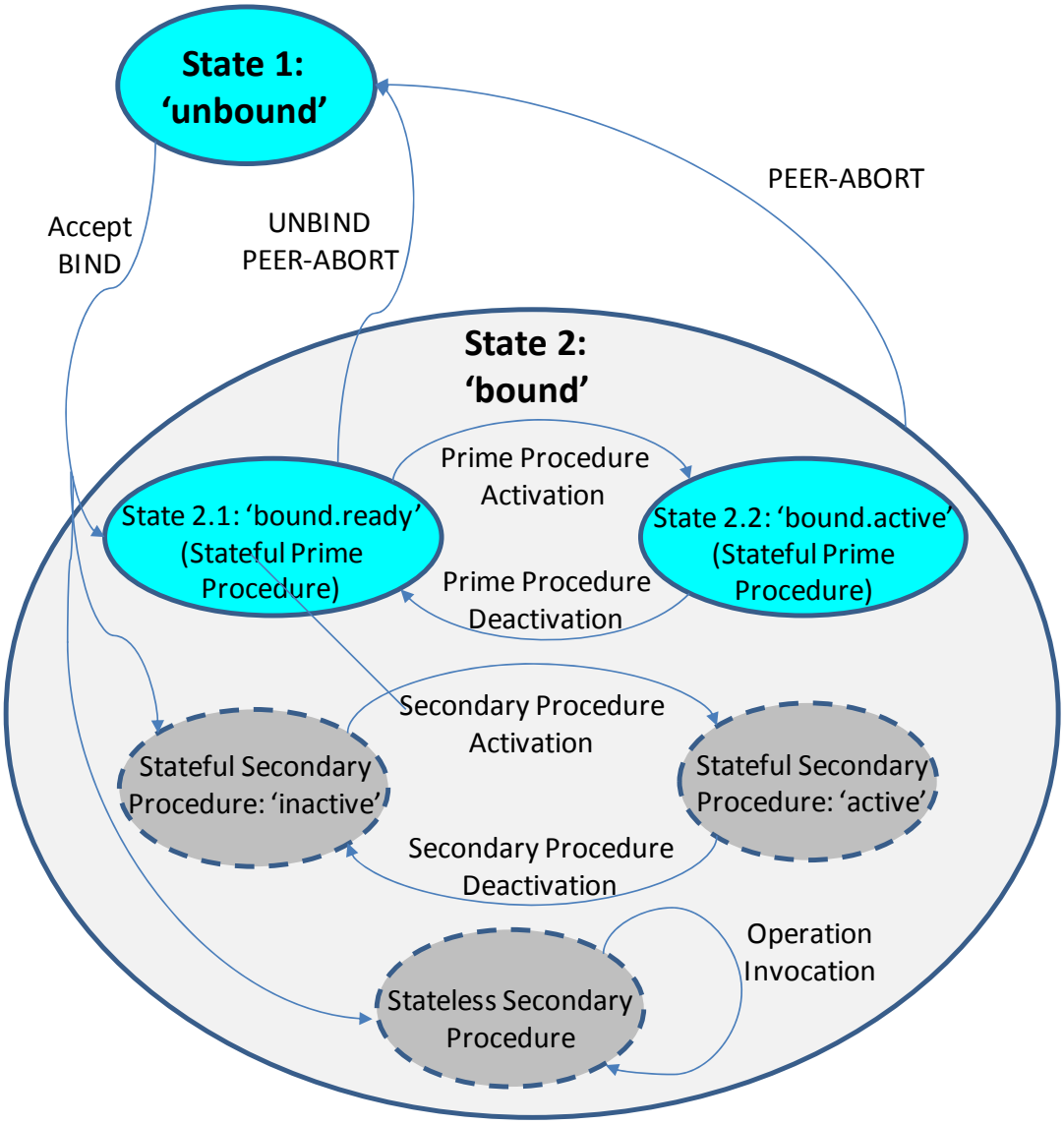

Figure 2-2: Service and Procedure States (Stateful Prime Procedure)

NOTE – The activation and deactivation of stateful procedures is further specified in 4.2.4.

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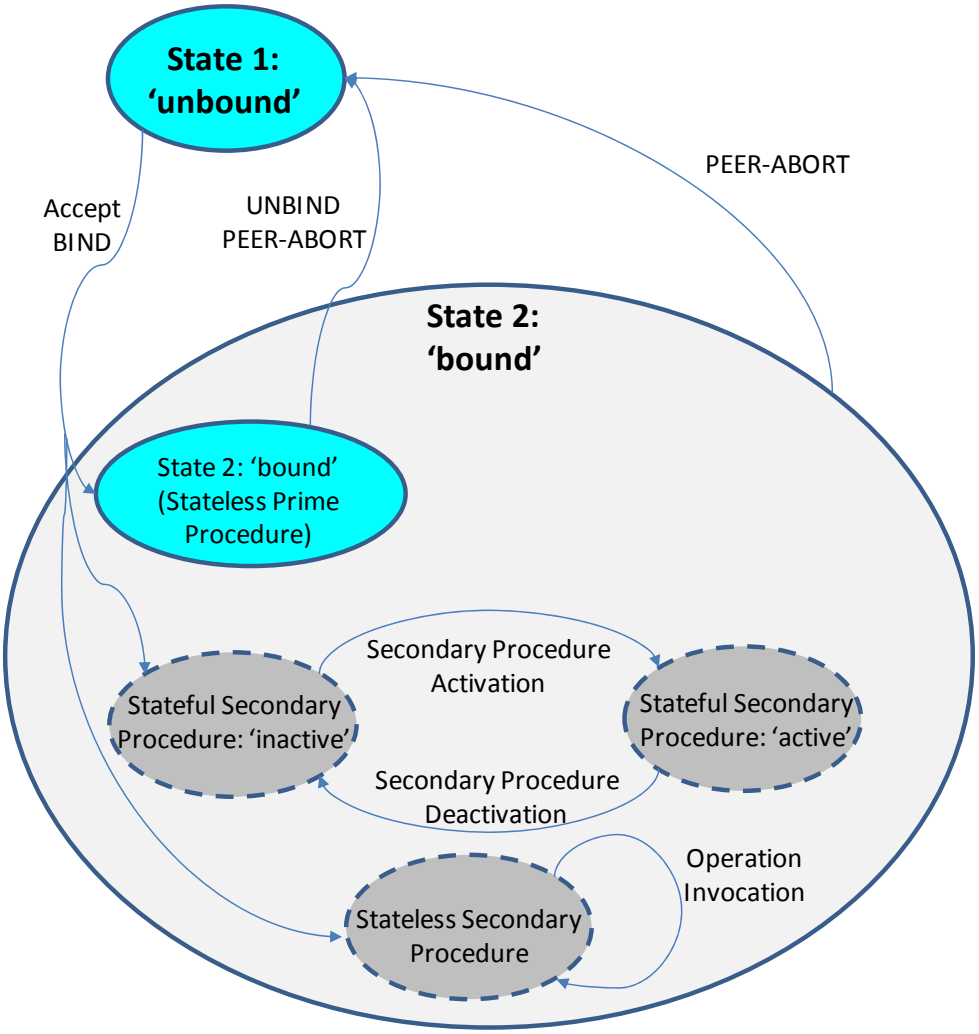

Figure 2-3: Service and Procedure States (Stateless Prime Procedure)

2.6.2 ASSOCIATION MANAGEMENT

Establishment and release of an association between the service user and the service provider is handled by the Association Control procedure specified in 4.3. All other procedures rely on the presence of such association and therefore establishment and release of the association must be coordinated between the procedure instances within a service instance.

An association is established by means of the BIND operation (see 3.4) which is always invoked by the service user. Before the BIND operation is completed, i.e., the BIND return is issued by the service provider, no further operation can be invoked. The only exception to this rule is the PEER-ABORT operation, which can be invoked by the service user if the BIND return is not received in good time. Once the association is established, other procedures used by the service can be operated according to their defined protocol.

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During the lifetime of the association, the prime procedure (instance) of the service instance and the Association Control procedure instance must cooperate to determine the applicable substate of the state 'bound' and the transitions between these states (see 2.6.1).

An association is released normally when an UNBIND operation is invoked by the service user and accepted by the service provider (the responder). An association may be aborted by either the service user or the service provider by means of the PEER-ABORT operation. An association may also be aborted because of a failure in the underlying communications system. Such failures are signaled to the local application entity by the 'protocol abort' event described in 4.3.3.1.9.5.

Conceptually, invocations of the operations UNBIND and PEER-ABORT will be received by the Association Control procedure, which will

a) verify the validity of the event according to the defined protocol and react accordingly;

b) inform all other procedures of the event;

c) respond to the event as defined by the protocol, e.g., by issuing an UNBIND return;

d) terminate the underlying communications connection, if applicable.

If a procedure needs to abort the association, e.g., because of a protocol error, it forwards this request to the Association Control procedure, which will invoke the PEER-ABORT operation and will inform all other procedures.

All procedures are expected to close down and release all resources associated with the service instance when they are notified of the termination event.

When an association is released or aborted, no further operations can be exchanged between the service user and the service provider. The systems may re-establish an association via a new BIND operation if that is consistent with the service instance provision period. However, status information from the prior association is not preserved unless specified differently by the service specification.

2.6.3 TECHNOLOGY SPECIFIC ASPECTS

This Recommended Standard defines building blocks for the specification of CSTSes. Provision of a CSTS in a real system also requires a specification of how the service is mapped to a communications service such that all invocations and responses of the service operations can be conveyed between the service user and the service provider. In order not to restrict the applicability of service specifications based on this Recommended Standard to a specific communications technology, as few assumptions as possible have been made about the characteristics of the underlying communications service (see 1.3.1).

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NOTE – While this Recommended Standard makes only a few assumptions on the underlying communications service, reference [2] specifies a communications service that is assumed to be used by default for CSTSes.

Elements of the CSTS interface between the service user and the service provider are specified in this Recommended Standard in terms of the operations that the service implements. These operations are realized by mapping the service operation invocations, acknowledgements, and returns to protocol data units that can be conveyed by means of the underlying communications service. This Recommended Standard conceptualizes such mapping in two parts:

a) operation invocations, acknowledgements, and returns are mapped to CSTS PDUs defined in annex F;

b) CSTS PDUs are conveyed by means of an underlying communications service.

Typically one CSTS PDU corresponds to the invocation, acknowledgement, or return of an operation. There is one exception in which multiple TRANSFER-DATA or PROCESS-DATA invocations are deliberately buffered and subsequently mapped to a single CSTS PDU (see 4.5.2.2.2.2 and 4.7.3.2.1). From the point of view of the service provider or service user application, the interaction between the service user and service provider is in terms of operations, but from the point of view of the application entities that implement the CSTS protocol, what is exchanged are CSTS PDUs.

The mapping of CSTS PDUs to an underlying communications service is intentionally outside the scope of this Recommended Standard. In order to achieve interoperability, the service user and service provider must conform not only to the service specification based on this Recommended Standard but also to an agreed-upon specification of the mapping of the service to the underlying communications service. The specification of a mapping of the service onto a particular communications service must address such points as:

a) selection of communications network(s) to ensure connectivity;

b) compatible configuration of protocol stacks (e.g., timeout values);

c) specification of port identifiers, and their translation onto the communications technology;

d) specification of security-related information.

Figure 2-4 illustrates a communications realization of a CSTS that results from such a mapping. The specification of a suitable mapping for CSTS to the Transmission Control Protocol (TCP) and the Abstract Syntax Notation One (ASN.1) is provided in reference [2].

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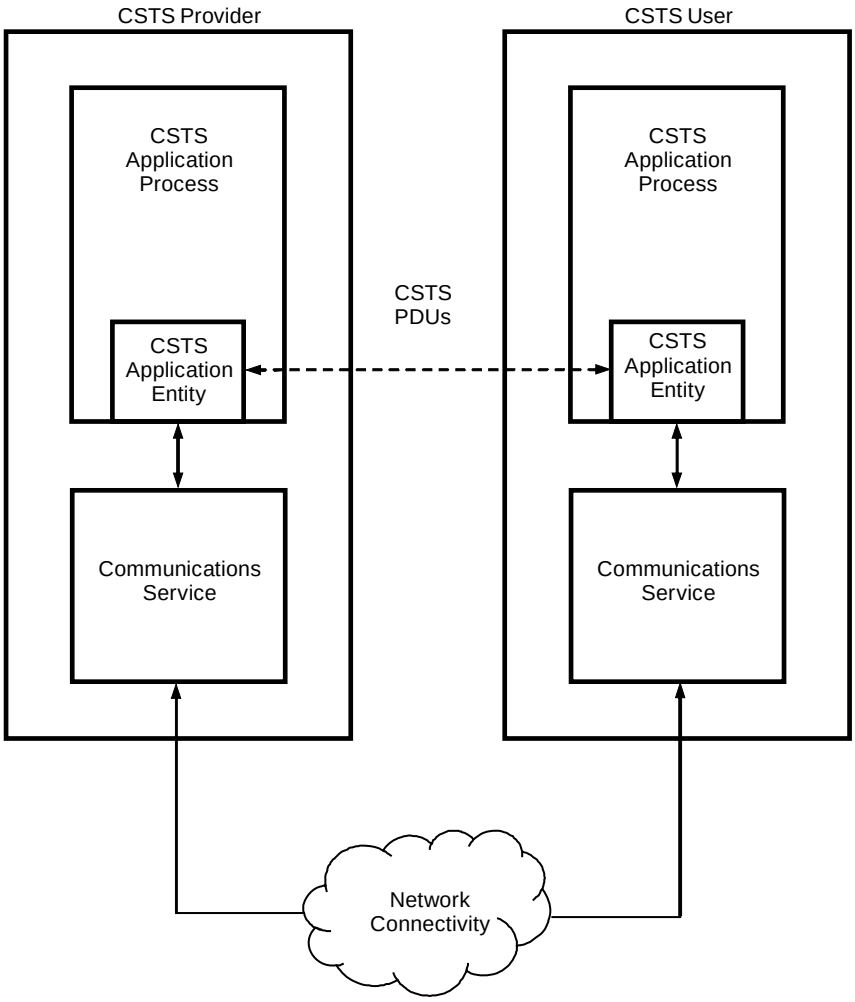

Figure 2-4: Communications Realization of a Cross Support Transfer Service

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3 COMMON OPERATIONS

3.1 OVERVIEW

This section specifies the operations that are used by the procedures defined in this Recommended Standard. Subsection 3.2 and 3.3 specify behaviors that are generally applicable to all operations. Subsections 3.4 through 3.13 specify individual operations that are used by the procedures defined in this Recommended Standard.

3.2 GENERAL CONSIDERATIONS

3.2.1 COMMON OPERATION BEHAVIOR

3.2.1.1 All invokers of confirmed operations shall implement a timer for the acknowledgement in case of three-phase operations or the return in case of two-phase operations. In case the timer expires, the service user may issue a PEER-ABORT.

3.2.1.2 On reception of the acknowledgement in case of three-phase operations or the return in case of two-phase operations, the invoker of the corresponding confirmed operations shall stop the timer.

3.2.1.3 All acknowledgements and returns shall include a `result` parameter that indicates whether the outcome of the operation was successful (`result` has the value 'positive') or unsuccessful (`result` has the value 'negative').

3.2.1.4 If `result` reported in an acknowledgement is 'negative', no return shall be generated.

3.2.1.5 If `result` reported in an acknowledgement or return is 'negative', the acknowledgement or return shall also include a `diagnostic` parameter, the value of which is descriptive of the reason for the negative result.

3.2.1.6 For certain values of the `diagnostic` parameter it shall be complemented by:

a) a visible string which value shall start with the diagnostic name identified in this Recommended Standard or in the service definition using this Recommended Standard;

b) additional diagnostic information whenever required by this Recommended Standard.

NOTES

1 Possible values of the `diagnostic` parameter are listed in the specification of each operation.

2 The visible string diagnostic is for troubleshooting purpose in order to allow implementers to add information to the diagnostic and to accommodate service-type or implementation-specific information. The value of the string, apart from the

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diagnostic name, shall be chosen by the implementers or defined in the CSTS specification.

3 The presence or absence of a visible string complementing the `diagnostic` value is specified in annex F.

3.2.1.7 The `diagnostic` parameter value may be extended by derived operations, procedures and services to support dedicated diagnostics.

3.2.1.8 Unless otherwise specified, all operation invocations, acknowledgements, and returns defined in this Recommended Standard can be extended.

NOTE – The extension capability is not explicitly mentioned in the rest of the document and is to be considered implicit for all operations.

3.2.2 PARAMETER TYPES

The types of all parameters shall conform to the abstract syntax specified in annex F.

NOTES

1 Some parameter types in annex F are chosen such that an extension is possible. For example, the `diagnostic` parameter can be extended so that a service can define its own diagnostics.

2 The syntax specified in annex F ensures the possibility of extension by defining fields that can be, whenever required, defined externally to the proposed syntax (e.g., operations extension).

3.2.3 PARAMETER CHECKING AND PDU VALIDATION

3.2.3.1 Validity checks shall be performed on the values of parameters associated with an operation.

NOTE – Rules governing the validity of parameter values are included in the specification of individual operations. General reasons for regarding a parameter value as invalid are specified in the following paragraphs.

3.2.3.2 A parameter value shall be treated as invalid if it is outside the range or not in the set of values permitted by the operation using the given parameter.

NOTE – A conforming implementation is capable of supporting the full range or set of values as specified in annex F and applicable to the service using this Recommended Standard.

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3.2.3.3 A parameter value shall be treated as invalid if it is in conflict with the value of another parameter in the same invocation.

NOTE – For example, the value of the `start-time` parameter in the invocation of an operation is invalid if it is later than the value of the `stop-time` parameter.

3.2.3.4 If a parameter value is not valid, the operation shall not be performed and, for confirmed operations, a report of the negative result shall be returned to the invoker.

3.2.3.5 While this Recommended Standard does not prescribe the sequence of checks for the parameters, the implementer shall document the implemented sequence.

3.2.3.6 A PDU shall be considered invalid if:

a) it contains an unrecognized operation type or a parameter of the wrong type; or

b) it is otherwise not decodable; or

c) the procedure identifier is not one of the specified service procedures identifiers.

3.2.3.7 In the case of an invalid PDU, the service provider shall abort the association using a PEER-ABORT with the corresponding `diagnostic` value (see 3.6.2.2.1).

NOTE – The invalid PDU case is not addressed elsewhere in this Recommended Standard.

3.2.4 AUTHENTICATION

NOTE – Requirements for security depend on the application and the system environment (e.g., whether closed or public networks are used or if access is only from physically restricted areas). In many environments, security may be provided by the communications service, transparently to the application. This Recommended Standard does not preclude the use of security features that are provided by the communications service or the local environment, nor does it assume the availability of such features.

3.2.4.1 The service shall provide the following options with respect to the level of authentication of invocations and responses of operations:

a) ‘all’: all invocations, acknowledgments, and returns, except the invocation of PEER-ABORT, shall be authenticated;

b) ‘bind’: only the BIND invocation and return shall be authenticated;

c) ‘none’: neither invocations nor responses shall be authenticated.

3.2.4.2 Complex Management and Utilization Management shall agree on the level of authentication to be required for a given service instance and shall configure service user and service provider accordingly.

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